

Distribution and detectability of the Southern Bell Frog¹ *Litoria raniformis* in the South Australian River Murray Floodplain

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ABSTRACT

Records of sites occupied by Southern Bell Frogs *Litoria raniformis* determined from call recordings in the South Australian River Murray floodplain were compiled for the period September 1995 – April 2006 from a number of published and unpublished sources. These records revealed that while this frog is reported along the length of the river floodplain ($n = 80$), the majority of these sites occur in the Riverland region ($n = 54$). Fewer records occurred in the lower reaches of the river. This relationship was found to be statistically significant in a sub-set of the total data. Wetlands that were temporary, managed to have alternating wet and dry phases or had significantly fluctuating water levels constituted 66% ($n = 53$) of all sites recorded, with permanent wetlands making up the remaining 34% ($n = 27$) of sites. This relationship was found to be significant in a sub-set of the total data. Wetlands that were surveyed more than once over the course of a year, and at which Southern Bell Frogs were recorded at least once were analysed for seasonal variability in detection rate. This revealed that 92% of surveys conducted in November ($n = 26$) detected calling frogs compared to 50% of surveys conducted in September ($n = 34$). While the findings of this paper are preliminary in nature the broad trends observed suggest that managed wetlands and other anthropogenic manipulations of water levels can play a role in the conservation of this frog species and requires further investigation. Additionally, ongoing monitoring would benefit from studies that further refined the optimal detection period for this frog.

Key words: bell frog, *Litoria raniformis*, water regime, distribution, detection.

Introduction

The decline of the Southern Bell Frog *Litoria raniformis* throughout its geographic range in New South Wales, Victoria, the Australian Capital Territory, Tasmania and South Australia has been well documented (Tyler 1998; Mahoney 1999; Pyke 2002). It is listed as 'Vulnerable' under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999 and has threatened species status in all states in which it occurs. In South Australia the historic distribution of the Southern Bell Frog includes locations along the length of the River Murray and in the lower south-east extending northwards towards Keith. In the south-east it has declined and become scarce, although it still remains abundant in a few scattered areas. It has been described as locally abundant in parts of the River Murray valley (Tyler 1998; Walker and Goonan 2002).

The descriptions of current distribution in the River Murray floodplain have been largely based on the Environmental Protection Authority's (EPA) annual frog census, a community survey in which members of the public record frog calls from water bodies throughout South Australia during a single week in September (Goonan et al. 1997, 1998; Walker et al. 1999, 2000; Walker 2002, 2003; Walker and Goonan 2001, 2002). These surveys are an ongoing

source of valuable abundance and distributional data for South Australia's frog populations. However, the number of sites at which Southern Bell Frogs are recorded may well be an underestimation of the true proportion of sites actually occupied owing to the census design with a single survey period generally in early September. This period is used because it is believed to be the time when the greatest number of species will be detected. Underestimation will occur if the detection probabilities for a single species, such as the Southern Bell Frog, change over the course of a year and the timing of the single survey does not coincide with the optimal detection period for that species.

Of additional interest to the conservation of this species is the type of water body occupied at the time of detection. In a review of Southern Bell Frog biology, Pyke (2002) found that while it was unclear to what extent this species breeds in wetlands that were either permanent, semi-permanent or ephemeral, there was enough evidence to suggest that it would do best in water bodies that were ephemeral or fluctuate significantly in water level. This species may also depend on areas where both permanent and temporary wetlands exist and will move into new areas in response to flooding (Ehmann & White 1996, Wassens 2005).

¹Referred to as the Growling Grass Frog in Victoria

In addition to the annual census, other recent studies and monitoring of wetlands in the South Australian River Murray floodplain have also provided information on the current distribution of the Southern Bell Frog. Because these studies have included multiple sampling periods over the course of a breeding season, some initial analysis of optimum survey time is also possible. Hence the aims of this paper were: (i) to document the recent recorded distribution of the Southern Bell Frog in the South Australian River Murray floodplain; (ii) to relate the recorded distribution to hydrological regimes, and (iii) to examine optimum sampling times for the Southern Bell Frog in the South Australian River Murray floodplain. This paper is a preliminary assessment of existing data and the findings are not intended to be definitive, rather they are intended to identify possible future research and management actions for the Southern Bell Frog in this region.

Methods

Records of calling by Southern Bell Frogs in the South Australian River Murray floodplain were collected for the period 1 September 1995 – 12 April 2006. These records were compiled from a number of published sources such as wetland species inventories (Herbert 2000), the Environmental Protection Authority's (EPA) frog census reports (Walker & Goonan 2002, Walker 2003), and River Murray wetlands baseline surveys (SKM 2004, SA MDB NRMB 2006). Unpublished data were used, including monitoring records from wetlands managed by the South Australian Department of Environment and Heritage (DEH) (Harper unpublished data), and records from the EPA frog census (EPA, SA frog census unpublished data). In addition, opportunistic records by the author during 2005 – 2006 were also included.

All frog location data used in this study were collected with the call recording technique employed in the EPA's annual frog census. This method involves recording frog calls at each site, 1–3 hours after dusk for a period of five minutes. Frog calls are later identified, and an estimate of frog abundance is made either through the EPA frog census or by the persons making the recording. Abundance classes are one, few (2 – 9 frogs), many (10 – 50) and lots (>50).

Data from the EPA frog census are collected in one survey period during the first weeks of September, and were available for the period 1995 – 2003. DEH wetland monitoring data were typically collected in two survey periods; one early in the breeding season (September to November) and one later in the breeding season (December to January). The first round of the River Murray wetland baseline surveys were conducted in 2003 and 2004. The 39 wetlands in this survey were typically sampled for frogs on three or four occasions between November 2003 and September 2004. The second round of these baseline surveys were conducted in 2005 in an additional 22 wetlands. Frog surveys were typically conducted on four occasions between May and November.

Wetlands in which the Southern Bell Frog was recorded were classified as one of four types: 1) Managed wetlands in which the wetland had alternating wet and dry cycles;

2) temporary wetlands - those filled by over bank flows or those into which water was pumped to simulate flooding; 3) fluctuating wetlands - those wetlands that responded strongly (i.e. large increases in wetted area) to increased river heights (in this study only wetlands directly affected by the 2005 weir raising trials were included in this category); and 4) permanent wetlands – those at which the water level was relatively stable. Wetlands were placed into these categories based on their description in Jensen et al. (1996), SKM (2004, 2006) or site visits. In all instances the latest information available was used to make these classifications.

Based on the differing geomorphological characteristics of the South Australian section of the River Murray (Mackay & Eastburn 1990, Young 2001, SKM 2006), sites were classified as occurring in one of four zones (Fig. 1). The Riverland section between Chowilla and Overland Corner (228 km of river frontage) is an area of confined floodplain that contains over 120 wetlands, approximately half of which are permanent and half are ephemeral (Jensen et al. 1996). However, owing to river regulation many ephemeral wetlands are no longer regularly flooded by overbank flows; a problem that has been particularly acute since 2000. The Gorge section between Overland Corner and Mannum (266 km of river frontage), is typified by steep cliffs and a reduced floodplain area. There are still a large number of wetlands in this area (>150), with approximately 55% permanent and 45% ephemeral (Jensen et al. 1996). In the Lower Murray Swamps, between Mannum and Wellington (76 km of river frontage), the river is largely confined between levee banks and there is little exchange between the main river channel and the floodplain. The final section is the Lakes and Coorong, which lies between Wellington and the Lower Lakes. This final section is 56 km in length.

Results

A total of 213 records of Southern Bell Frogs were collected from 80 separate sites along the South Australian River Murray floodplain between 11 September 1995 and 12 April 2006 (Fig. 1). This includes 104 records of the Southern Bell Frog at 48 locations from the annual South Australian Frog Census. Where multiple records exist in the frog census data for a single site, the separation of repeated records is one year or greater. Sites from the annual frog census at which Southern Bell Frogs were not recorded are not considered in this paper, because detailed site information was not available for all wetlands. In the two rounds of the Wetland Baseline Survey frog surveys were conducted at 58 wetlands, one of which was excluded from further analysis because the frog surveys were conducted when the wetland was dry. In these surveys the Southern Bell Frog was recorded in 18 wetlands on 26 occasions from 73 surveys. The DEH wetland monitoring data included records of Southern Bell Frogs at 17 wetlands that were surveyed on 84 occasions to yield 50 positive records. Opportunistic records collected included positive records from 14 wetlands. The Southern Bell Frog was recorded in two or more of the data groups at 13 sites.

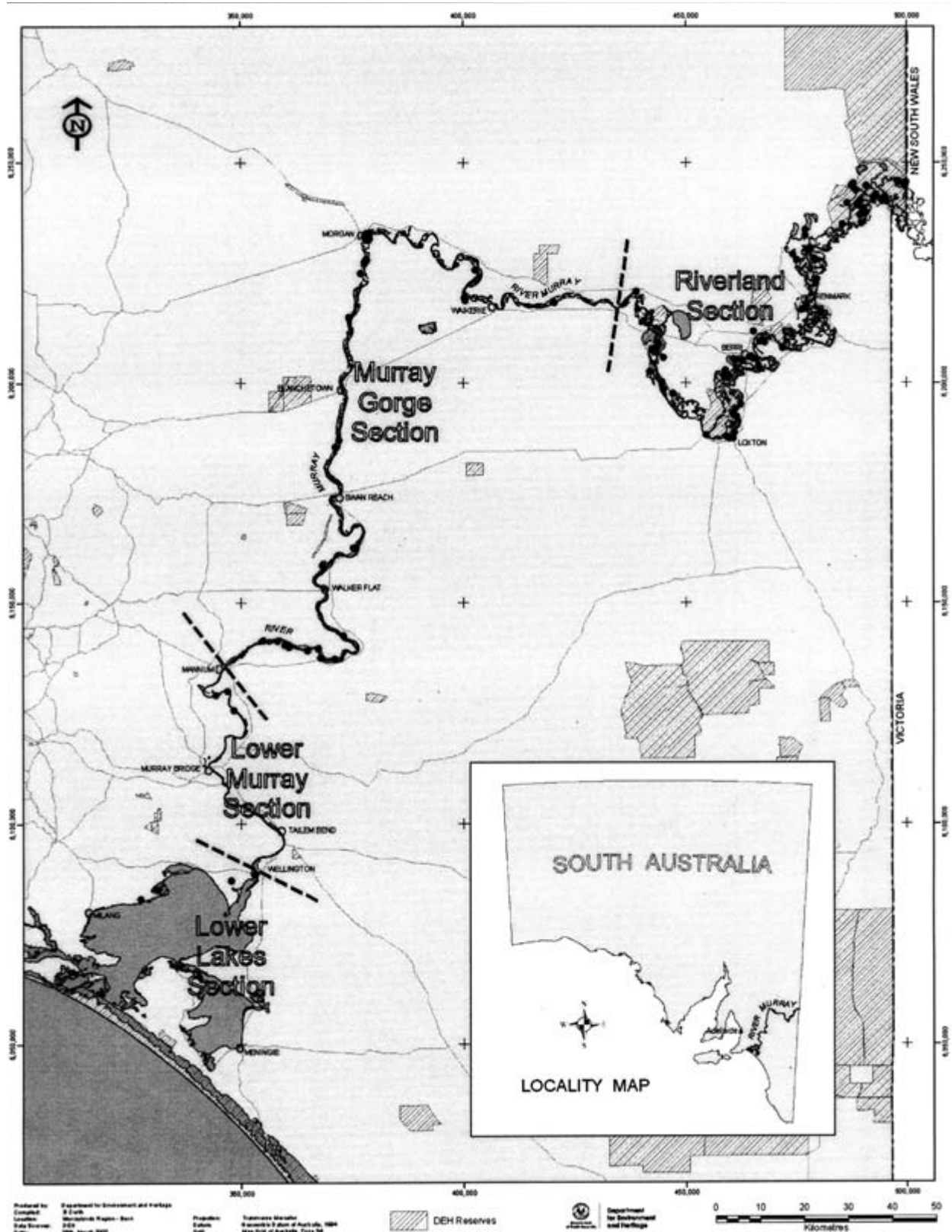


Figure 1. Distribution of the sites at which Southern Bell Frogs were recorded between 1995 – 2006 ($n = 80$ sites) in the South Australian River Murray floodplain. Shaded areas indicate National Parks or other conservation reserves.

From the 80 locations at which Southern Bell Frogs were recorded in this compiled data set, 27 were permanent water bodies, 25 were wetlands managed to have alternating wet and dry phases, 16 were ephemeral and 12 were permanent water bodies with fluctuating water levels (Table 1). Hence 66% of all records were from wetlands

with fluctuating water levels. As sites with negative results from the EPA frog census were not included in this study and the DEH wetland monitoring data are from managed wetlands only, no statistical comparison of the combined data with respect to wetland type was made. However, the two rounds of the River Murray Wetlands Baseline

Table 1. Distribution of sites at which southern bell frog calls were identified in the South Australian River Murray floodplain by water body type and location.

River Section	Managed Wetland	Temporary Wetland	Fluctuating Wetland	Permanent Wetland	Total Number of Sites
Riverland (South Australian Border to Overland Corner).	20	10	11	13	54
Murray Gorge (Overland Corner to Mannum).	4	5	0	10	19
Lower Murray Swamps (Mannum to Wellington).	0	1	0	2	3
Lakes and Coorong (Wellington to the Coorong).	1	0	1	2	4
Totals.	25	16	12	27	80

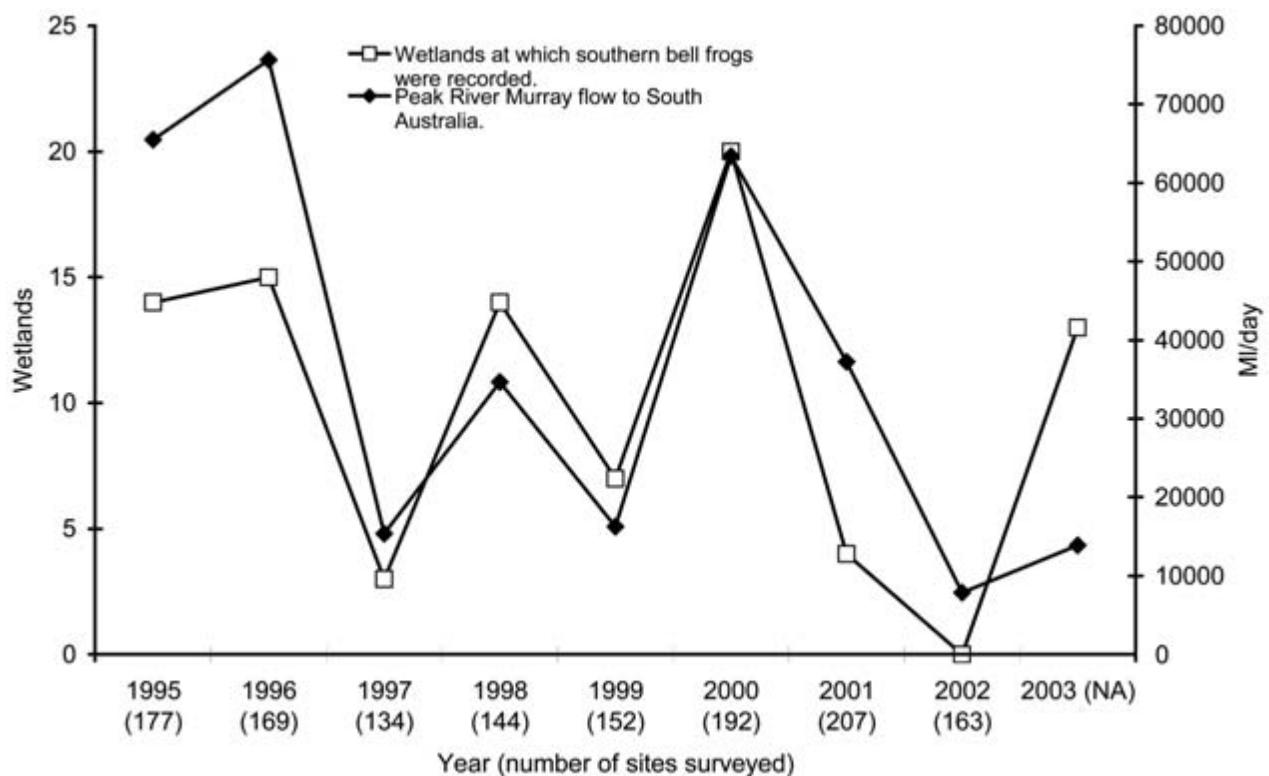
surveys included 36 permanent wetlands and 27 wetlands with fluctuating water levels. Southern Bell Frogs were recorded at six of the permanent wetlands and 12 of the wetlands with a more variable water regime. These differences were statistically significant ($\chi^2 = 5.83$, $df = 1$, $P = 0.016$) indicating that for this data set the frequency of surveyed sites at which Southern Bell Frogs occurred was dependent on water regime.

The relationship between water regime and number of sites at which Southern Bell Frogs were recorded was explored further by comparing the number of occupied sites in a given year with annual South Australian rainfall (Bureau of Meteorology 2007) and the annual peak daily Murray River flow to South Australia (Department of Water Land and Biodiversity Conservation 2006). Only EPA frog census data were used for this comparison because it represented the most consistent sampling over a 9-year period (1995 – 2003). There was no significant relationship between annual South Australian rainfall and number of sites at which frogs were recorded (Rank Correlation, $r = 0.36$, $n =$

9, $Z = 1.03$, $p = 0.336$). There was, however, a significant relationship between peak daily River Murray inflow to South Australia (Rank Correlation, $r = 0.76$, $n = 9$, $Z = 2.16$, $p = 0.021$) (Fig. 2).

The maximum number of sites at which the bell frog was detected (combined data) occurred in 2005, when it was recorded at 26 sites (Fig. 3). The majority of records was of sites with frog abundance in class 2 (2 – 9 individuals) (Fig. 4). Wetland size at which Southern Bell Frogs were recorded ranged from 1 – 712 ha (mean = 105.5 ± 157.8 , modal size = 6.6 ha, $n = 55$). There was no correlation between wetland size and abundance class (Rank Correlation, $r = 0.23$, $n = 55$, $P = 0.867$, $Z = 0.165$).

The combined data revealed that the greatest concentration of sites at which Southern Bell Frogs were recorded (54 sites) occurred in the Riverland section (Table 1). The next highest concentration (19 sites) occurred in the Gorge section. The lowest number of sites occurred in the Lower Murray Swamps (3 sites) and the Lakes and

**Figure 2.** The relationship between the number of sites at which Southern Bell Frogs were recorded in the South Australian E.P.A's Annual frog census (1996 – 2003) and peak daily River Murray inflows to South Australia recorded at Lock 6.

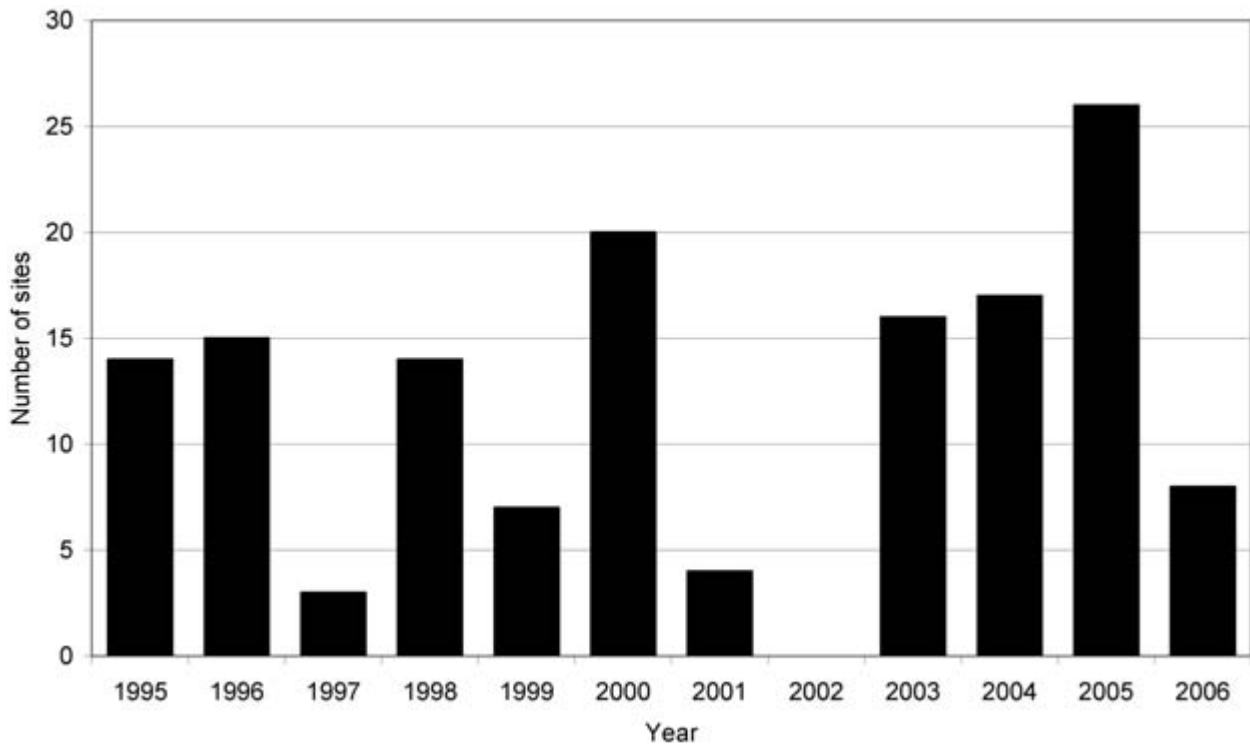


Figure 3. Number of sites per year along the South Australian River Murray floodplain at which southern bell frog calls were identified between 1995 – 2006.

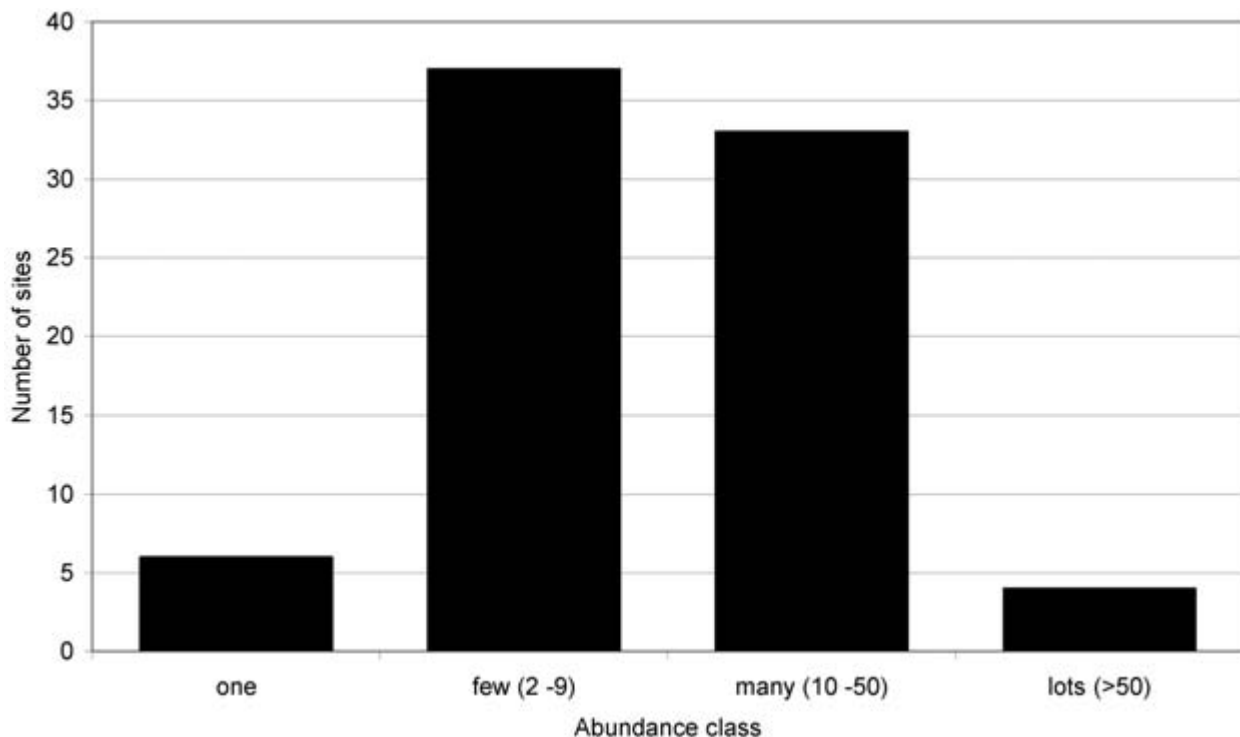


Figure 4. Maximum estimated abundance class of calling Southern Bell Frogs from the 80 sites at which it was recorded between 1995 – 2006.

Coorong (4 sites). Because sites with negative results from the EPA frog census were not included in this study and all but one of the wetlands in the DEH wetland monitoring data occur in the Riverland section, no further comparisons of the combined data with respect to location were made. However, the River Murray Wetlands Baseline surveys sampled a total of 21 wetlands each for the Riverland and Murray Gorge and 5 and 12 wetlands for

the Lower Swamps and Lower Lakes, respectively. From these surveys a total of 9 wetlands with Southern Bell Frogs were recorded in the Riverland section, five in the gorge section, none in the Lower Swamps and two in the Lower Lakes. The frequency of surveyed sites at which Southern Bell Frogs were found was dependent on location when the Riverland section was compared to the combined lower river sections ($\chi^2 = 6.514$, $df = 1$, $P = 0.011$).

To assess the optimal survey times for Southern Bell Frogs using the call detection method, data were examined from wetlands that had been sampled on two or more occasions during a breeding season or a Calendar year at which at least one positive record was made. Sites that had been sampled in multiple years were also included in this analysis. These records consisted of 66 records from DEH wetland monitoring data, 66 records from the two rounds of the wetland baseline surveys and seven records from the frog census and personal observations, and included 71 positive and 68 negative records from 30 wetlands. For sites surveyed on multiple occasions either within or between years, the proportion of surveys yielding positive results varied between months ranging from 0.09 in February to 0.92 in November (Fig. 5). No Southern Bell Frogs were detected in April, May or June. For statistical analysis of temporal variability in detection rate and to allow for the low number of records in some months data were grouped into four 2-monthly periods, commencing with August–September. The frequency of sites at which a positive result was recorded was dependent on the time of year at which the survey was conducted ($\chi^2 = 31.52$, $df = 3$, $P < 0.0001$). Greatest differences between observed and expected frequencies occurred in the February – March period.

Discussion

The combined records show a distribution of the Southern Bell Frog in the South Australian River Murray floodplain that has the largest concentration of sites occurring in the Riverland section (Fig. 1). Because this study combined data from a number of different sources over a 12-year

period, it is inevitable that there are sampling biases in the results. The number of sites occurring in the lower three sections of the South Australian River Murray may well be under represented because the survey effort in these sections has not been as great as it has been in the Riverland section. This occurs primarily as a result of two factors. In the first instance there are a greater number of managed wetlands in the Riverland section where ecological monitoring, including amphibian monitoring, is required as a condition of obtaining a water licence. Second, a greater level of response from community surveys such as the EPA frog census can be expected from areas of relatively higher human populations, such as the Riverland. However, the results from the River Murray Wetlands Baseline Survey, which had an even distribution of sampling sites along the river floodplain, shows that the proportion of sampled sites at which calling Southern Bell Frogs were recorded was greater in the Riverland section (SKM 2004, 2006). This suggests that sample bias is not the sole reason for the observed distribution pattern.

In the same manner, there appears to be an increase in the number of sites at which Southern Bell Frogs were recorded between 1995 and 2005 (see Fig. 3), but this probably represents differences in the source and number of records available. The period 1995 – 2002 is comprised entirely of EPA frog census records, while the remaining period is supplemented with additional data. These latter surveys also had multiple sampling rounds that included surveys coinciding with periods of maximum detection, so were more likely to return positive results. However, the significant relationship between River Murray inflows to South Australia and the number of sites at which

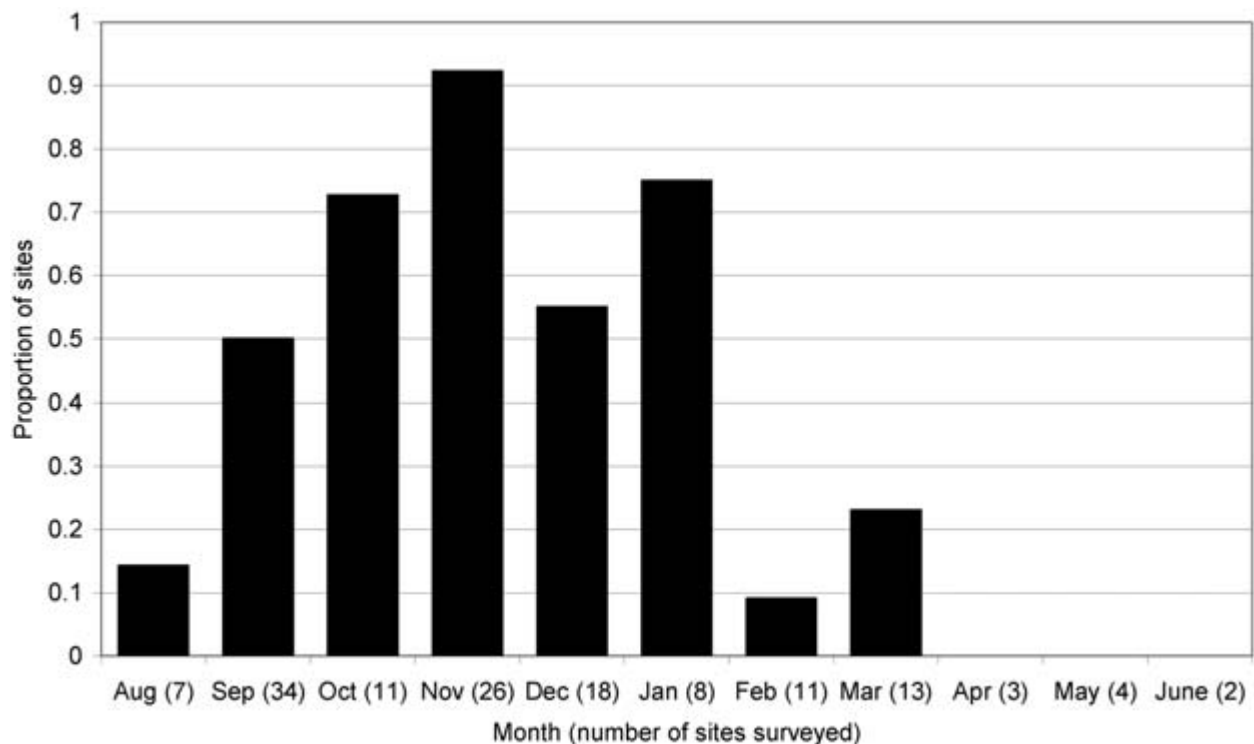


Figure 5. Proportion of surveys ($n = 71$) at which Southern Bell Frogs were recorded in 30 wetlands, that were surveyed on two or more occasions over a breeding season or Calendar year. Total number of surveys = 139.

Southern Bell Frogs were recorded in the Annual Frog Census strongly suggest the importance of a variable hydrological regime to this species within the South Australian River Murray floodplain (Fig. 2).

Calling male frogs were recorded at nearly three times as many locations in the Riverland compared to the Gorge section of the South Australian River Murray floodplain. This distribution may be influenced by the greater variability in hydrological regime that exists in the Riverland section, which leads to a greater potential for inundation of temporary wetlands and for fluctuation in water levels at more permanent water bodies. Fluctuating water levels and flooding have been shown to stimulate breeding in Southern Bell Frogs in the semi-arid region of Western NSW (Wassens 2005). Variability in river flow has declined dramatically in both river sections, but the actual variation in river height has remained greater in the Riverland section during the period of this study (DWLBC 2006). In addition, the Riverland area contains a greater number of managed wetlands; that is, wetlands with flow control structures where alternating wet and dry cycles have been reintroduced. Although weir manipulation trials (experimentally raising weir levels to simulate minor flooding) were conducted in both the Riverland and Gorge sections of the river in 2005, water levels were raised at three locks in the Riverland section and only one in the Gorge section (SKM 2006). In 2005—the year in which the greatest number of occupied sites was recorded—managed wetlands accounted for 42% of sites with frogs ($n=11$ sites), wetlands affected by the weir raising trials accounted for 27% ($n=7$) of sites, River Red Gum watering trials (pumping water into temporary wetlands to water the surrounding trees) accounted for 8% of sites ($n = 2$), and permanent wetlands accounted for 29% of sites. Hence, in 2005, 71% of call records were from wetlands with a variable hydrological regime.

For all data combined, calling males were found more often in managed temporary and fluctuating water bodies (66% of all records), than they were in permanent water bodies. This finding suggests movements of the Southern Bell Frog into temporary wetlands occurs regularly in the South Australian River Murray floodplain. In 2004, Southern Bell Frogs were recorded in Lake Littra, the site of a River Red Gum *Eucalyptus camaldulensis* watering trial in which water was pumped into this temporary wetland four years after it was last flooded. Assuming that the Southern Bell Frog cannot persist in these temporary wetlands when dry for such extended periods, the frogs would have had to move at least 300 m overland from the nearest permanent water (Department for Environment and Heritage 2004). In radio-tracking studies Wassens (2005) found that this species was highly mobile and occupied different aquatic habitats over time, including both temporary and permanent water bodies. Movements of up to 212 m over a 24-hour period were recorded. Seasonal movements of 300 – 500 m between water bodies have been recorded in the green and golden bell frog *Litoria aurea* (Goldingay and Newell 2005a), and between years a movement of 1.25 km between breeding sites (Goldingay and Newell 2005b).

This current study could not identify the source of the frogs moving into temporary wetlands nor the habitat features that comprised or linked these sites to the locations where calling males were recorded. If the probability of Southern Bell Frogs moving into these newly flooded locations to breed is determined by their connectivity to existing local populations, then the identification and protection of these sites and links may be crucial for the conservation of this species. While the greater number of Southern Bell Frog records in the Riverland section may partly be explained by the greater variability in hydrological regime, other factors would also be expected to contribute to or explain this relationship. In particular, the majority of calling records in the Riverland (70%) were collected in National Parks, Game Reserves or other areas with formal conservation status (Figure 1). These areas may be free of threats that occur outside of reserves, or may contain features such as wetlands linked by relatively undisturbed vegetation which promote movements by frogs.

The significant relationship between time of year and the number of times Southern Bell Frogs were recorded demonstrated that detectability changes over the course of a year. Analysis of sites surveyed multiple times showed that surveys conducted between October and January are more likely to detect Southern Bell Frogs than surveys conducted at other times of the year (Figure 4). These findings suggest that the South Australian EPA's frog census, which consists of an annual September survey, may have underestimated the proportion of sampled sites occupied by Southern Bell Frogs in the past. However, the timing of the frog census is designed to coincide with the period in which the greatest number of frog species can be detected. Hence, those with a specific interest in the Southern Bell Frog in South Australia should supplement the census results with additional surveys conducted later in the year. Additionally, in subsequent years, the collection of presence/absence data from repeated surveys, at a proportion of sites would enable a more accurate calculation of detection probabilities to be made in the future (Mackenzie et al. 2002, 2003, Heard et al. 2006).

While this study provided an overall distribution pattern for the Southern Bell Frog in the South Australian River Murray floodplain and suggests reasons for this distribution, it does not answer questions relating to the abundance (as only estimates of calling male frogs were made) and population viability at the recorded sites. Hence, the likelihood of populations persisting in these areas in the long-term is not known and requires population studies. What is highlighted though is that the majority of records are from managed wetlands and other water bodies with fluctuating water levels. This strongly suggests that research of this issue would be valuable so that effective management of regulated wetlands or other anthropogenic manipulations of water levels can be implemented where required. This will become increasingly important to the conservation of the Southern Bell Frog in this region if the current low levels of water inflow to South Australia persist. On-going monitoring studies of this species would be improved by using repeated survey data with sampling periods conducted at the most appropriate time of year.

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